Fermilab
PPD/MD/Engineering Analysis Group

Stress and Stability Calculation for the Cell Size of 6.0 cm x 3.87 cm

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Introduction

A proposed TASD detector has a size of 15.7 m x 15.7 m with a horizontal and vertical PVC extrusions alternated as shown in Fig 1. The cell geometry is 6.0 cm (beam direction) x 3.87 cm (high). The estimated weight for each filled plane is around 36,000 lbf. It is a giant and heavy structure needed to be understood fully. This study is trying to address some of these issues.

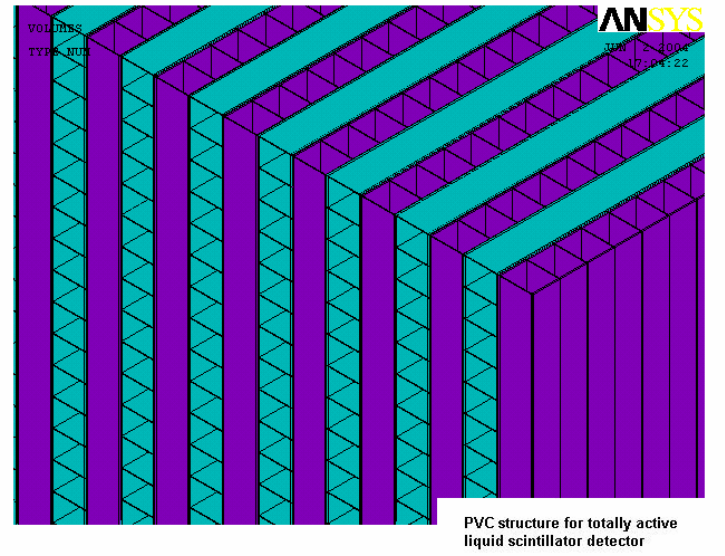

Fig 1 Structure of TASD

The Vertical Extrusion

The vertical extrusion is filled with the mineral oil up to 15.7 m. Its bottom section will be subjected to 19 psi pressure. For a thickness of t (side) = 3mm and t(rib)=2 mm, the calculation gives a maximum stress of 1400 psi for the interior cell as shown in Fig 2. A thicker wall is required for the exterior cell due to its 6.0 cm span length. The 6 mm wall thickness with a slight large corner radius gives a maximum stress of 1,000 psi as shown in Fig 3.

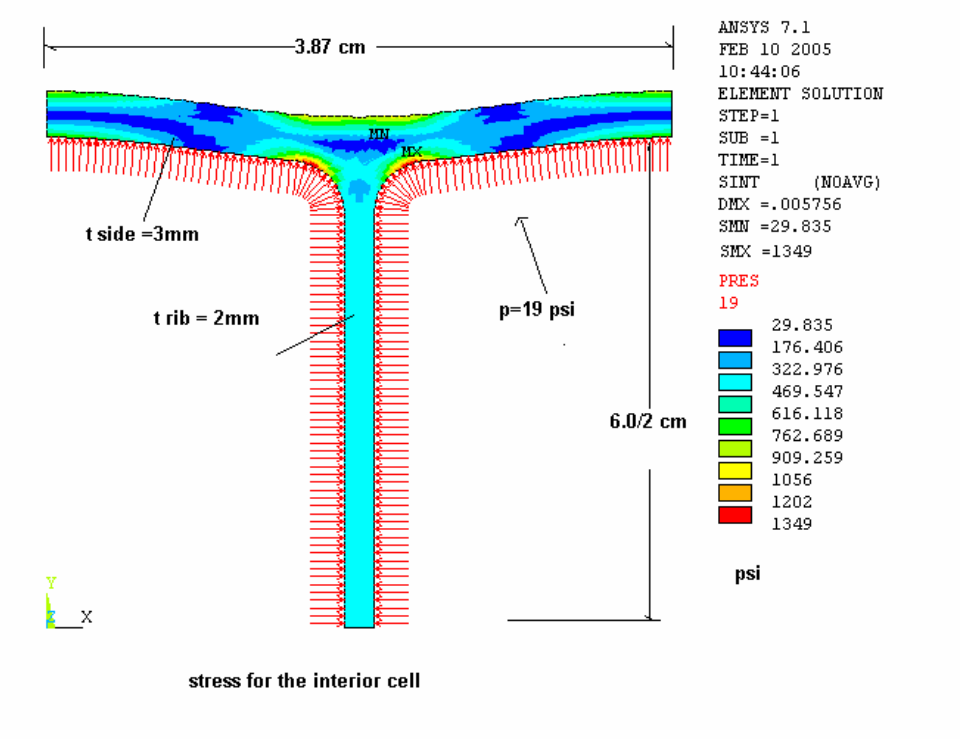

Fig 2 Stress for the interior cell

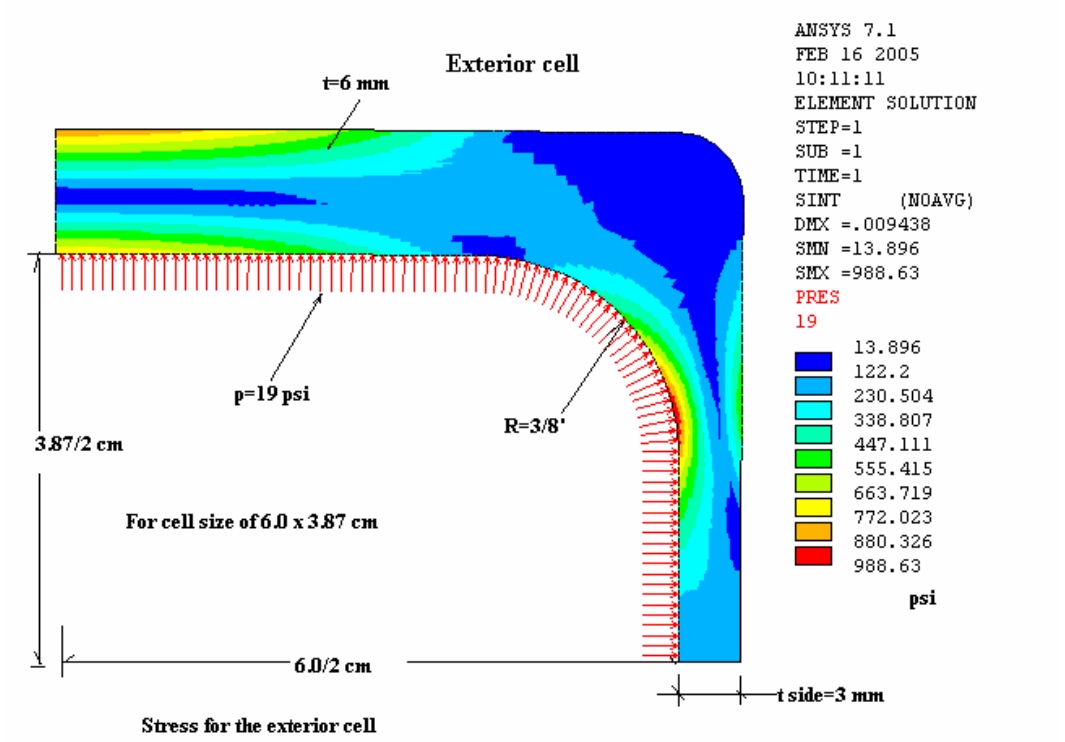

Fig 3 Stress for the exterior cell

The Horizontal Extrusion

There are several calculations needed for the horizontal extrusion since the horizontal extrusion is loaded with both a hydrostatic load within its own module and gravitation load from top modules. So, first one is to check the local stability for the lowest cell of the horizontal extrusion. By applying all possible structure load from top, the calculation shows that the extrusion has a SF=7.7 against the lowest cell buckling __ pancake mode as shown in Fig 4. The working stress, as shown in Fig 5, is also well below to the allowable, which is defined as 1,000 psi. Third calculation is to check the stability of rib (2 mm) subjected to 19 psi due to the separation of the rib and side wall in adjacent vertical extrusion. Fig 6 shows that SF =3.3 for a 2 mm wall (rib).

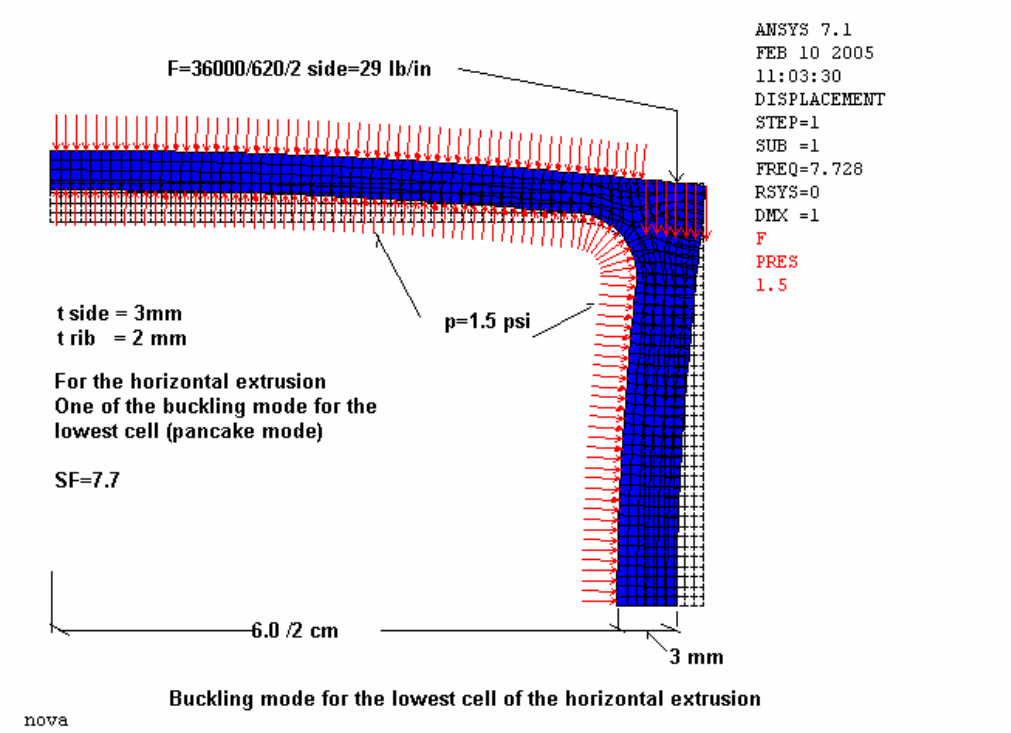

Fig 4 Buckling mode for the lowest cell of the horizontal extrusion

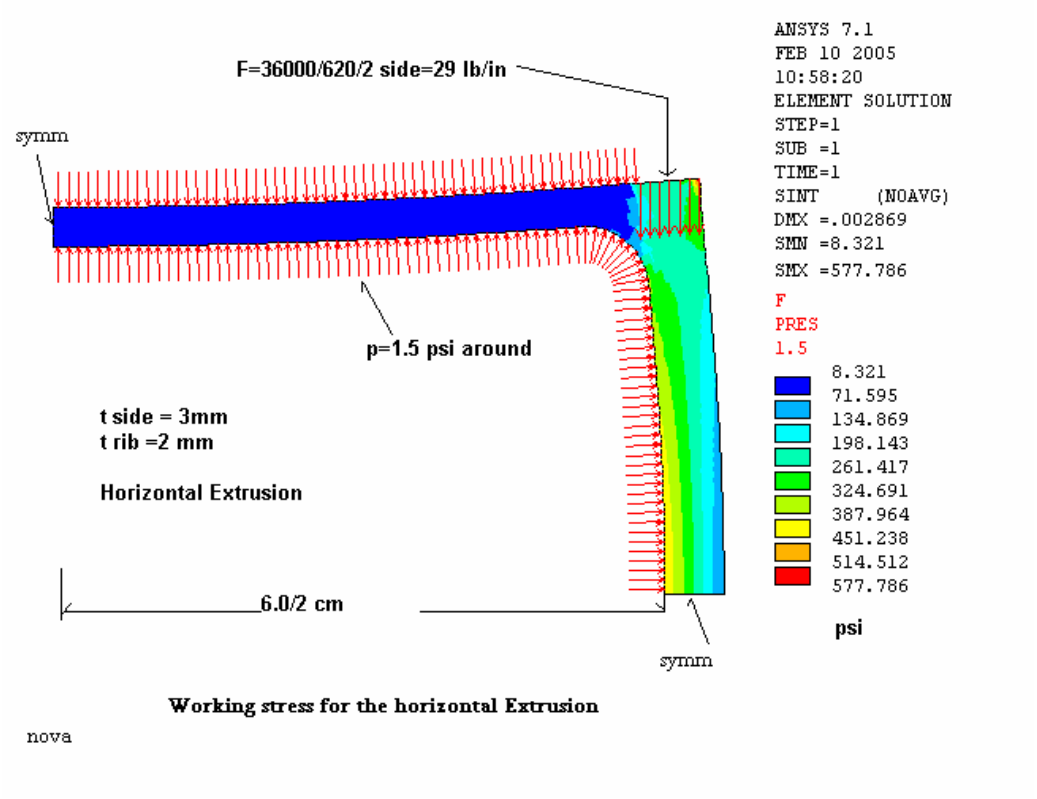

Fig 5 Working stress for the horizontal extrusion

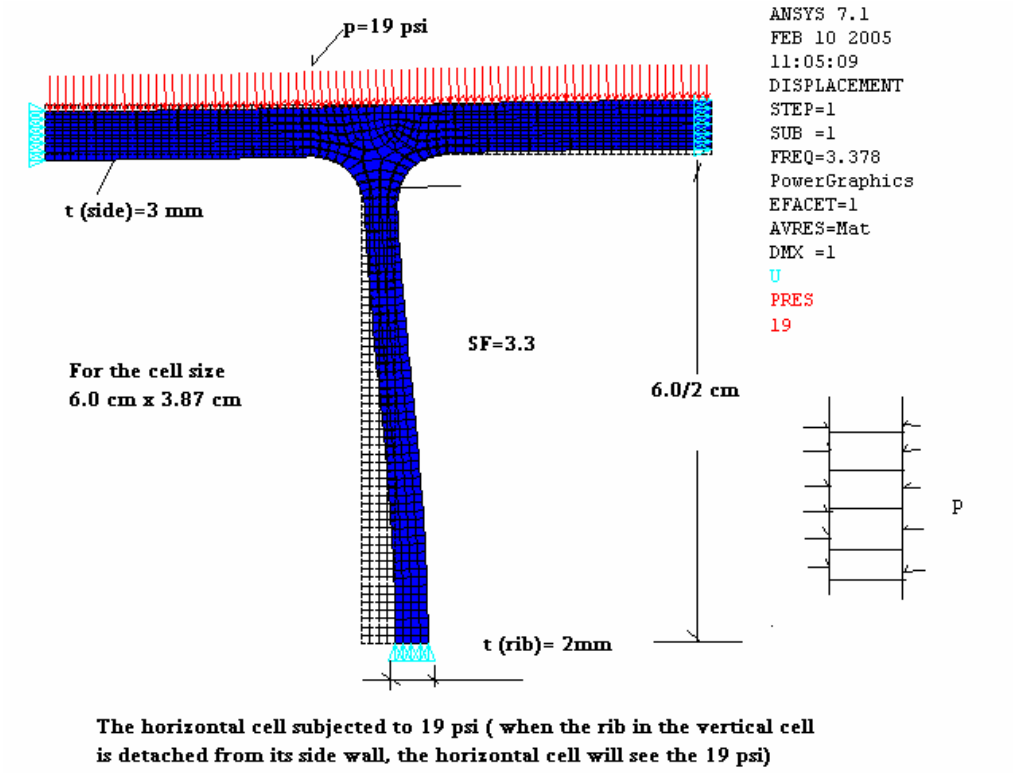

Fig 6 Horizontal cell subjected to 19 psi

Vertical and Horizontal Extrusion Glued

A 3-D Ansys model is used to study the case where the vertical and horizontal extrusion are glued together. Two cases have been studied. The table 1 is a summary of the result for both fully glued and partially glued (30% area glued) case. The model has a symmetry boundary condition around, except one surface which is allowed to move freely along the beam directions as shown in Fig 7. The maximum stress is around 550 psi for a fully glued case and 1,000 psi for a partially glued case as shown in Fig 8 through Fig 12.

Table 1 Summary of the Calculation Result for t(side wall)=3 mm and t(rib)=2mm

	Vertical and horizontal Fully glued	Vertical and horizontal Partially glued (30%)	No glue
Deflection* (mils)	1.5	2.5	5.7
Maximum Stress (psi)	560	1,000	1,400
Maximum shear stress in the mid plane (psi)	70	240	N/A

* Note: The deflection stated above is the deflection at the outer edge of the horizontal extrusion.

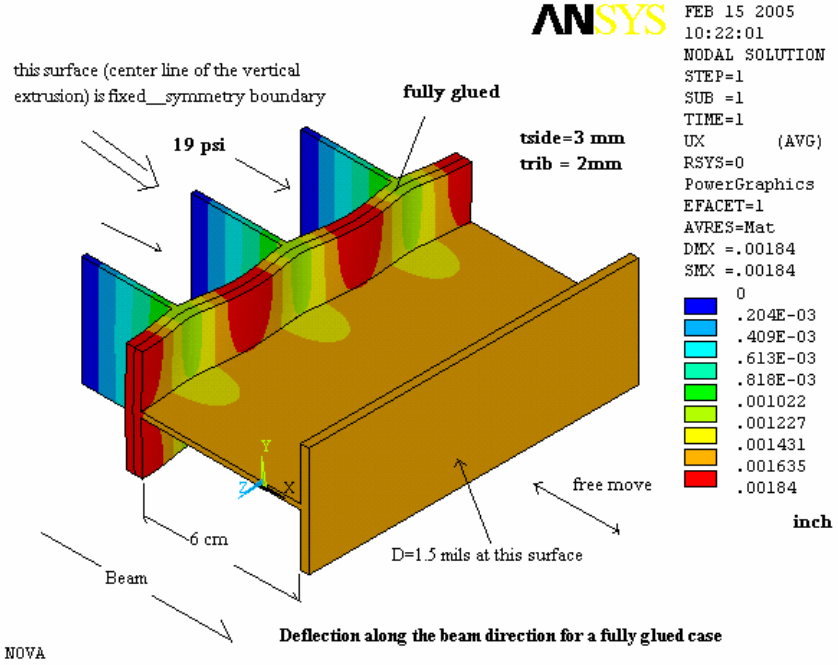

Fig 7 Deflection along the beam direction for a fully glued case

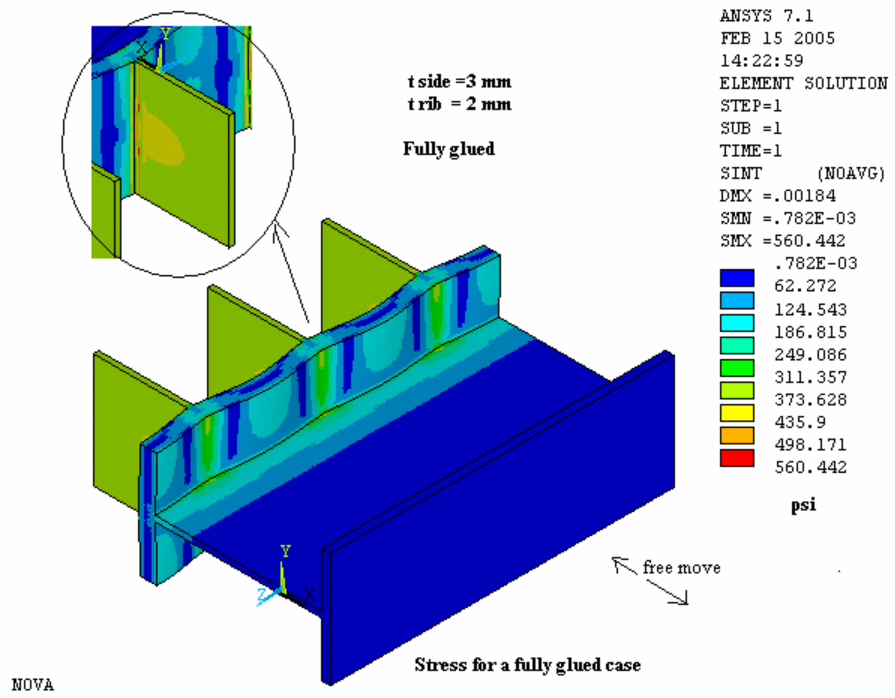

Fig 8 Stress for a fully glued case

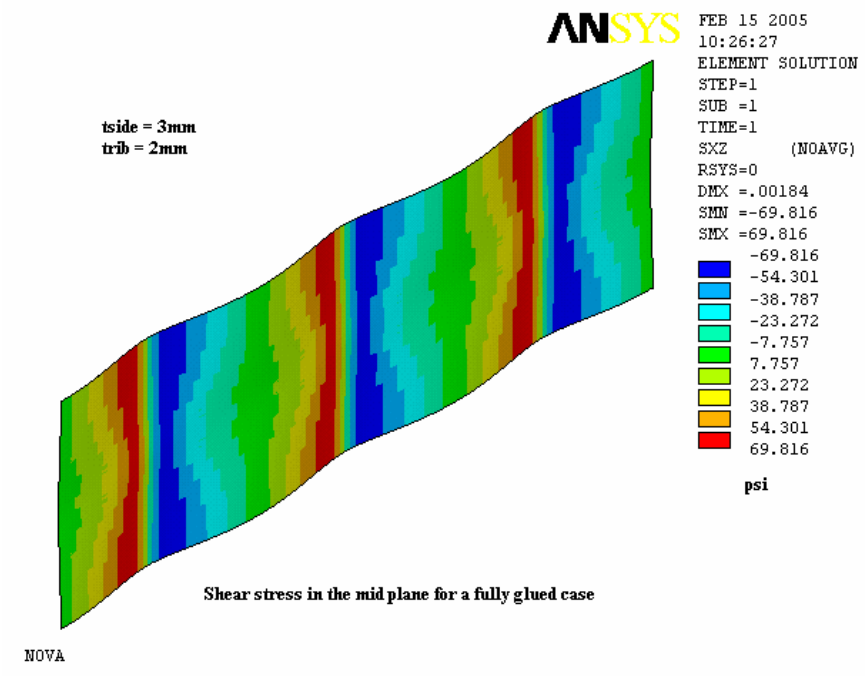

Fig 9 Shear stress in the mid plane for a fully glued case

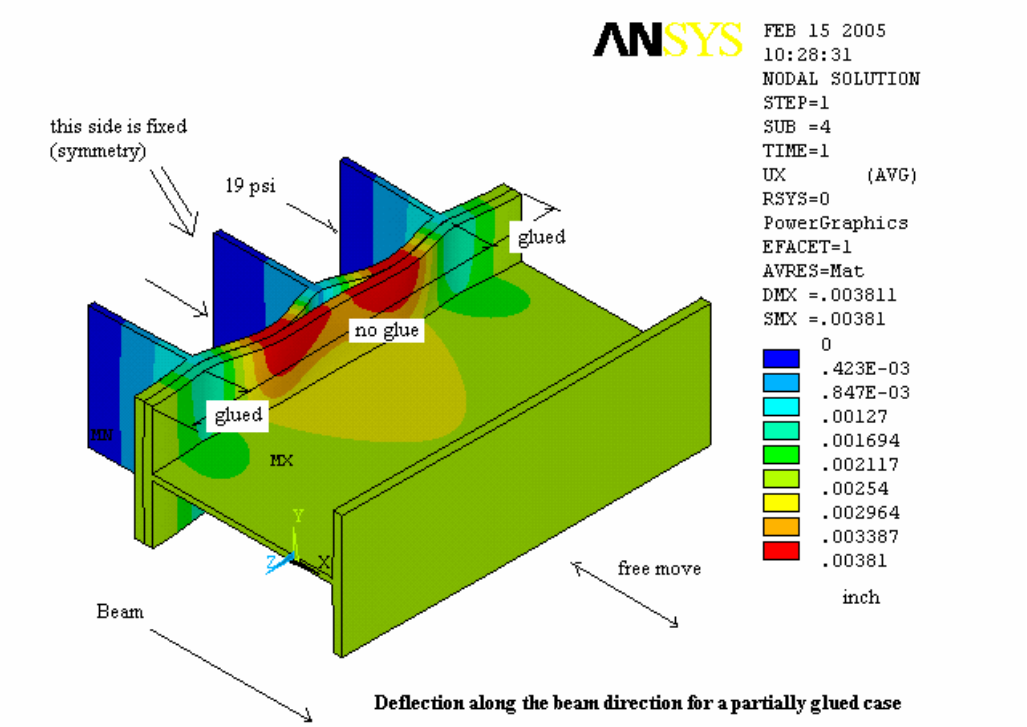

Fig 10 Deflection along the beam direction for a partially glued case (30% areas glued)

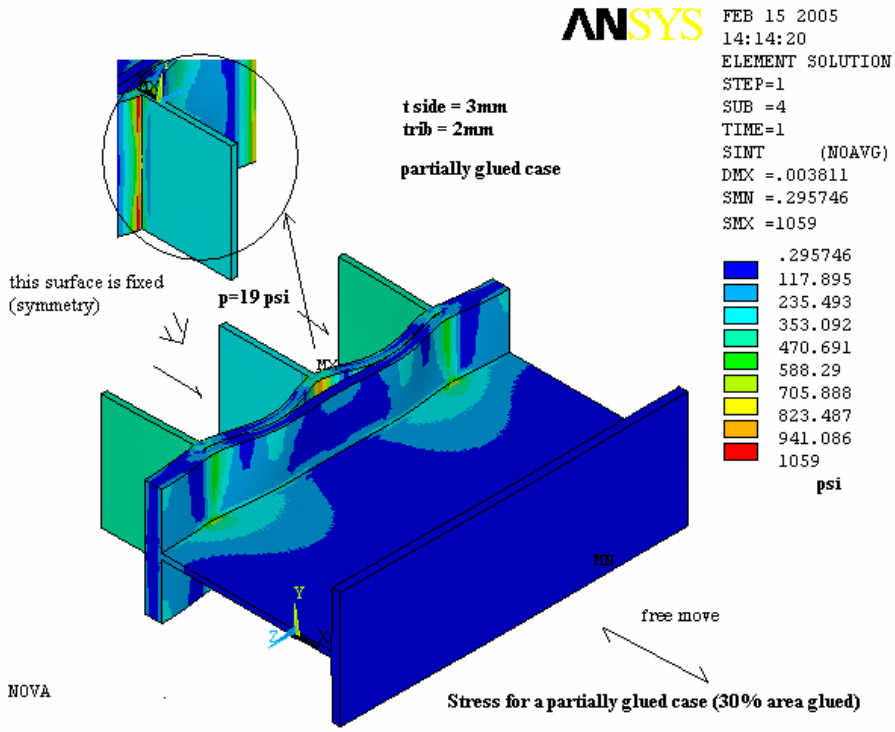

Fig 11 Stress for a partially glued case (30% area glued)

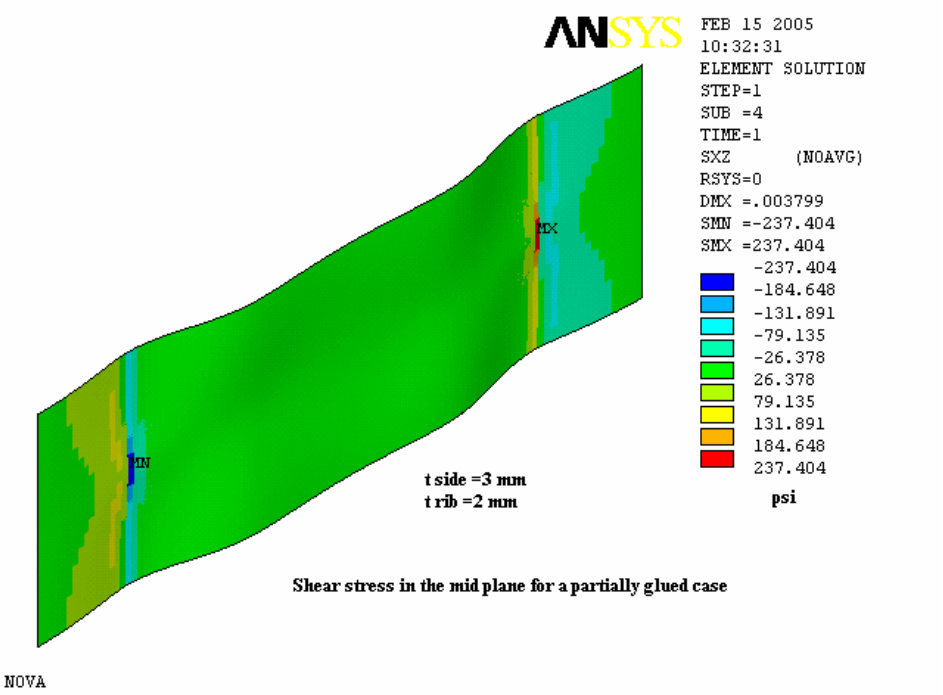

Fig 12 Shear stress in the mid plane for a partially glued case